Integral shell mirrors for the Constellation X-ray Mission Hard X-ray Telescope

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Constellation-X HXT

Integral (Whole Shell) Electroformed Nickel Optics

Advantages

- **Based upon proven technology, i.e. SAX, JET-X, XMM**
- **Best angular resolution, XMM achieved 15 arcsec HPD**
- **Smallest number of elements to assemble, by over order of magnitude**

Challenges

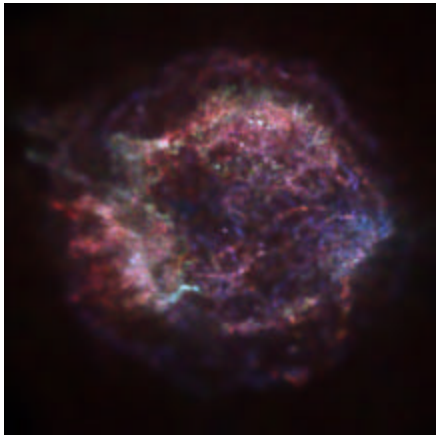
- **Difficult to apply multilayer coatings to interior of closed shell**
- **Nickel substrates are heavier than glass or alminum, reduce mass**
- **Expensive beginning because a “superpolished” 360 deg mandrel is needed for each shell**
- **Smoother (cp XMM) replica surface required**

Significance of Better Angular Resolution

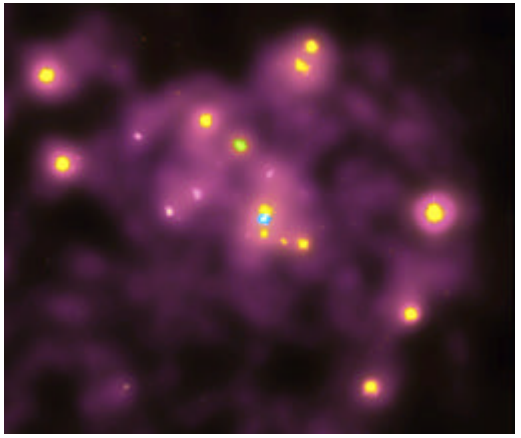
- Higher Sensitivity, most measurments will be background limited,
  15 arcsec resolution telescope is 4x more sensitive than 1arcmin telescope

- Imaging, spatially resolved spectroscopy

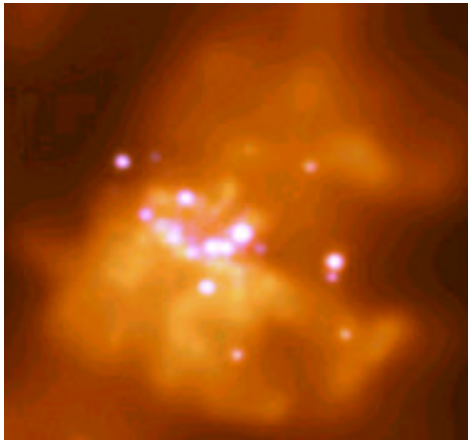
- Avoiding confusion



Cas A, True Color

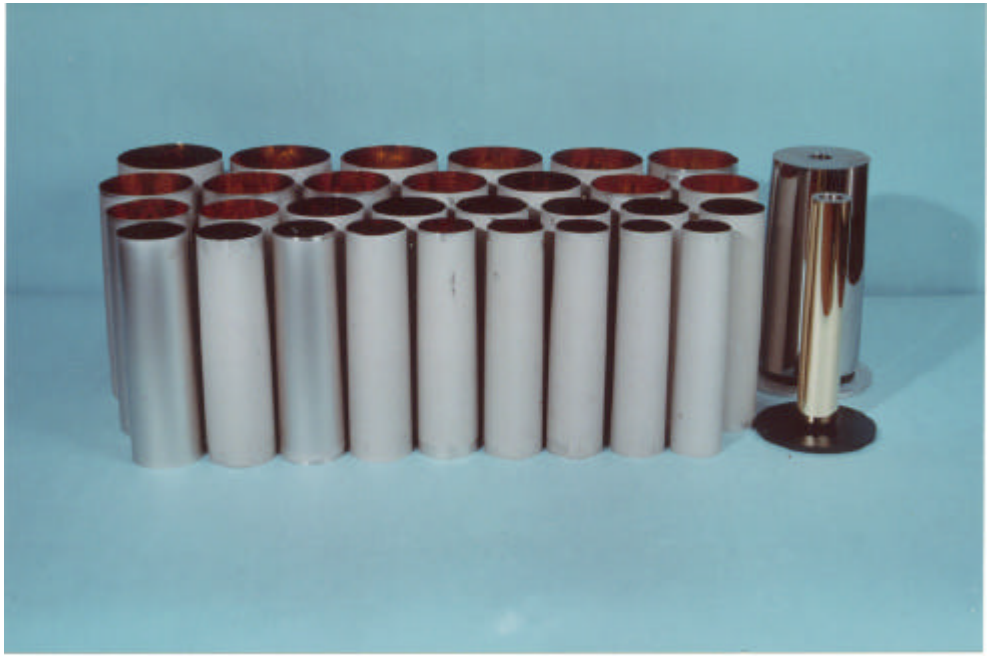


M31, Central 1 arcminute



M82, 1.5 arcminute

Electroformed Integral Shell Telescope



SAX mirrors. For JET-X, XMM, and Con-X HXT, scale up the dimensions and increase number of shells

Constellation-X HXT

Two Methods of Applying Multilayer Coatings

HXT Range of Shell Diameters is 10 to 40 cm

- For shell diameters 16 cm or larger, coating is deposited upon the replica by DC magnetron sputtering, - being studied by **SAO**

- For shell diameters < 16 cm, coating is deposited upon the mandrel and transferred to the replica upon separation, - being studied by **OAB**

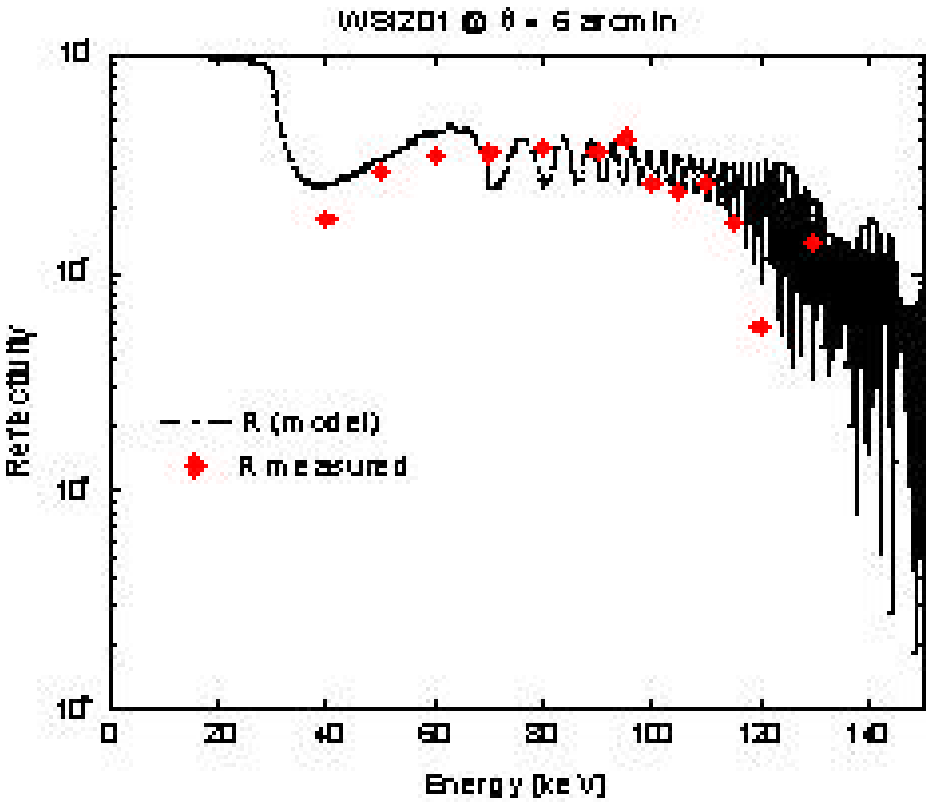
SAO Multilayer Deposition Facility

Capable of coating large area:

- Flat substrates
- Segmented substrates
- Interiors walls of cylinders with 15 to 40 cm diameter
- Outer surface of cylinders

Constellation-X HXT

Measurement of Hard X-ray Reflectivity of 300 Period Graded d-Spacing Multilayer at BNL (SAO)



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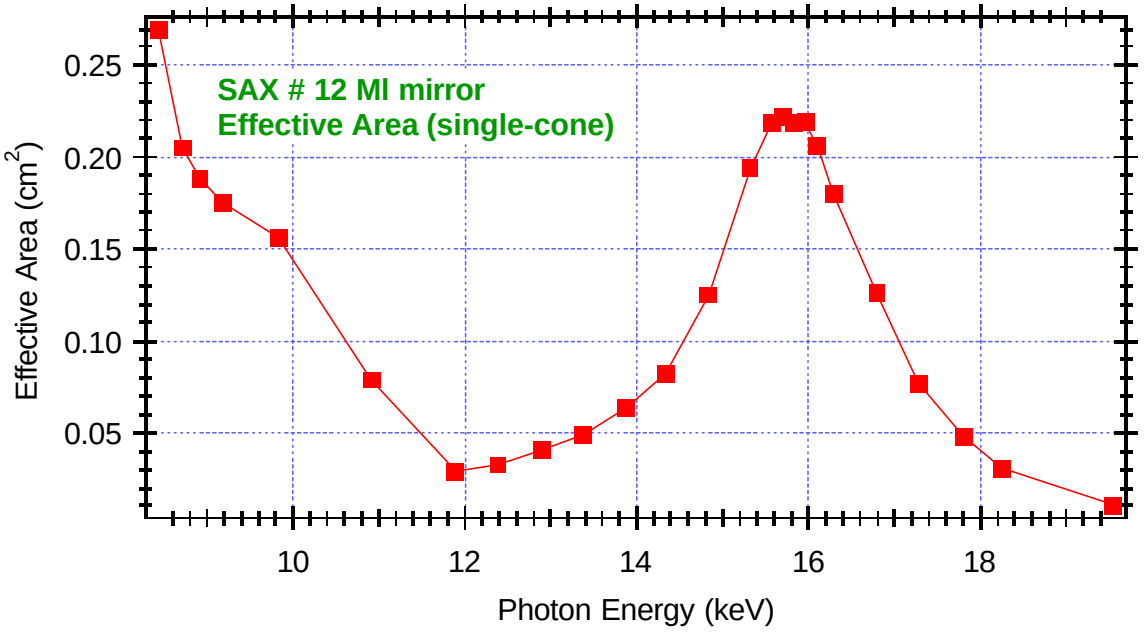
Measurement of Sample of Replica from SAX Mandrel with 10 Uniform Period Layers at the Panter Facility (OAB)



Multilayer Was Transferred Directly from Mandrel to Replica

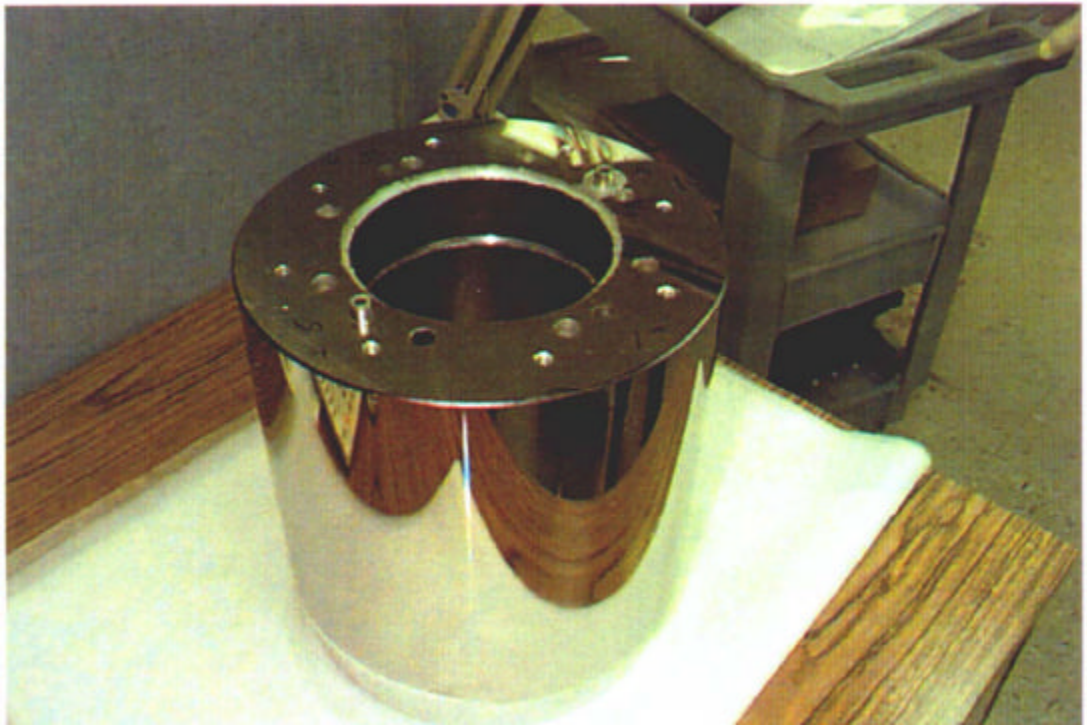
Constellation-X HXT

OAB “Superpolisher”

- **Currently Polishing Mandrel Provided by SAO**
- **Capable of Polishing Flats and Cylinders to 2 Ang. Rms**

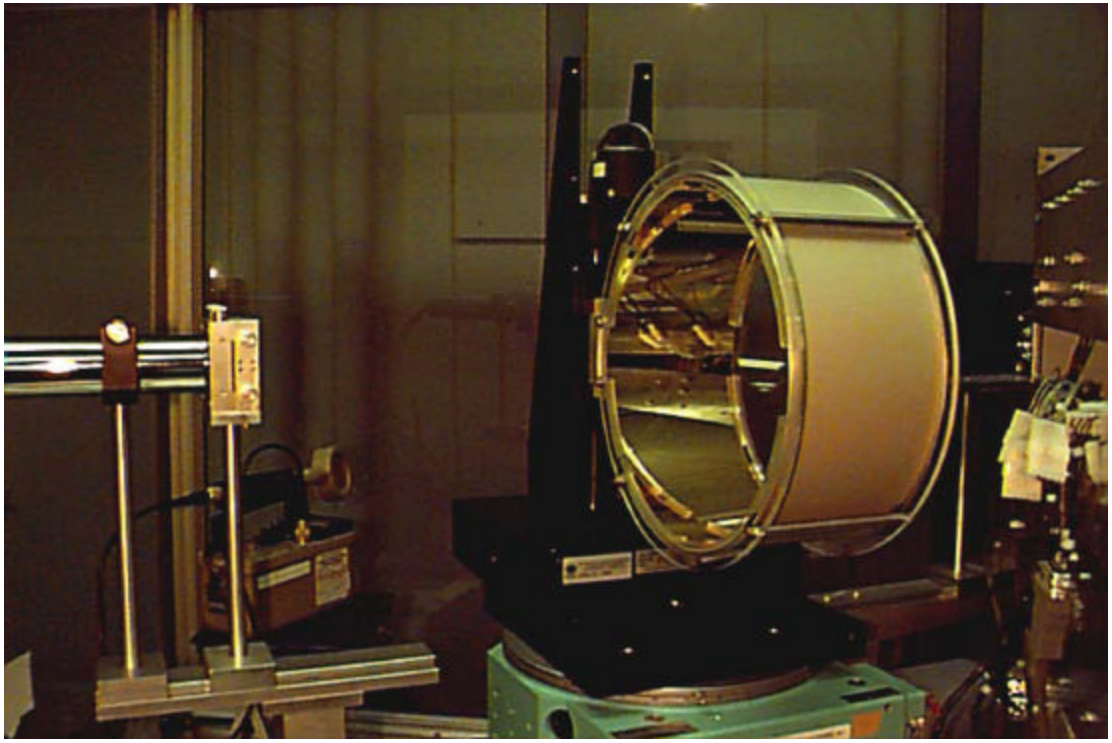
Mandrel, 28 cm Diameter

Fabricated by SAO (commerically), being “superpolished” at OAB



Replica, 28cm D.

(Mandrel Not in Final State of Polishing)



Delivered by OAB, to be coated at SAO soon

Constellation-X HXT

Near Term Goals

SAO | **SAO + OAB** | **OAB**

Coat current replica with 250 graded bi-layers

Complete polishing of mandrel

Coat flats with multilayers
- **Polished fused silica ("gold standard")**
- **Electroformed (real material**

Measure X-ray reflectivity of replica (pencil beams) BNL (May) and/or ESRF (June)

Coat 2nd replica provided by OAB with depth graded multilayers

Media Lario to produce 2nd replica with smoother finish
- **More polishing by OAB**
- **Refinement in electroforming**

Measure full aperture angular resolution of current replica at MSFC